Other aspects, advantages, and modifications are within the scope of the following claims.

What is claimed is:

1. An interferometry method for characterizing a test object, the method comprising:

forming an optical interference image by combining different portions of an optical wave front reflected from multiple surfaces of the test object and at least one reference surface, the multiple surfaces of the test object and the at least one reference surface defining a set of cavity surfaces;

recording an interference signal at different locations of the optical interference image in response to tuning the frequency of the optical wave front over a range of frequencies, wherein the interference signal includes a contribution from each pair of different surfaces in the set of cavity surfaces; and

for each location, calculating a frequency transform of the interference signal at a frequency corresponding to each of selected pairs of the different surfaces in the set of cavity surfaces and extracting the phase of the frequency transform at each of the frequencies corresponding to the selected pairs of surfaces.

2. The method of claim 1, further comprising:

calculating the frequency corresponding to each of the selected pairs of surfaces based on a nominal value for an optical path length difference for each of the selected pairs of surfaces and the frequency tuning rate.

3. The method of claim 1, further comprising:

transforming the interference signal into the frequency domain for at least one of the locations to produce a transformed signal having series of frequency peaks corresponding the pairs of different surfaces in the set of cavity surfaces, and selecting the frequencies corresponding to the selected pairs of surfaces from the series of frequency peaks.

4. The method of claim 1, wherein the selecting of the frequencies corresponding to the selected pairs of surfaces from the series of frequency peaks is based on the relative positions of the cavity surfaces.

5. The method of claim 1, wherein the frequency transform comprises a Fourier transform.

6. The method of claim 5, wherein the Fourier transform is a Fast Fourier transform.

7. The method of claim 5, wherein the Fourier transform is a sliding window Fourier transform.

8. The method of claim 1, wherein calculating the frequency transform comprises multiplying the interference signal with a window function and calculating the Fourier transform of the windowed interference signal at the frequency corresponding to the selected pair of surfaces.

9. The method of claim 8, wherein the window function is selected to reduce a contribution to the frequency transform at the frequency corresponding to one of the selected pairs of surfaces from at least one other pair of different surfaces in the set of cavity surfaces.

10. The method of claim 9, wherein the window function is a Tukey window or a Hamming window.

11. The method of claim 1, further comprising:

determining the surface profile of one of the test object surfaces based on at least some of the extracted phases.

12. The method of claim 1, further comprising:

determining a relative optical thickness profile between two of the test object surfaces based on at least some of the extracted phases.

13. The method of claim 1, further comprising:

determining the surface profile of multiple ones of the test object surfaces based on at least some of the extracted phases.

14. The method of claim 13, further comprising:

determining a relative orientation between two of the profiled test object surfaces based on at least some of the extracted phases.

15. The method of claim 1, wherein the at least one reference surface comprises one reference surface.

16. The method of claim 15, wherein the test object has a partially transparent front surface and a back surface, the front surface positioned nearer to the reference surface than the back surface, and wherein the front, back, and reference surfaces define a three-surface cavity.

17. The method of claim 1, wherein the at least one reference surface comprises two reference surfaces and the test object is positioned between the two reference surfaces.

18. The method of claim 17, wherein the test object has a partially transparent front surface and a back surface, and wherein the front, back, and two reference surfaces define a four-surface cavity.

19. The method of claim 18, further comprising:

interferometrically measuring a phase profile of a reference cavity formed by the two reference surfaces when the test object is not positioned between the two reference surfaces.

20. The method of claim 19, wherein the reference cavity is formed by removing the test object from between the two reference surfaces.

21. The method of claim 19, wherein the test object defines an aperture smaller than an aperture defined by the two reference surfaces.

22. The method of claim 21, further comprising compensating for the phase profile of the reference cavity for changes in the positions of the reference surfaces between the four-surface cavity measurement and the reference cavity measurement based on the phase

profile from each measurement corresponding to the two reference surfaces at the locations outside of the test object aperture.

23. The method of claim 19, further comprising determining a relative homogeneity profile of the test object based on the extracted phases, the relative phase profile of the reference cavity, and nominal values for the test object index and thickness.

24. The method of claim 19, further comprising calculating the absolute physical thickness profile of the test object based on a specified tuning range and a total change in the extracted phases over a period in which the frequency of the optical wave front is tuned over the specified tuning range.

25. The method of claim 24, further comprising determining the specified tuning range using a wavelength monitor.

26. The method of claim 19, further comprising calculating the absolute homogeneity profile of the test object based on a total change in the extracted phases over a period in which the frequency of the optical wave front is tuned over a selected tuning range.

27. The method of claim 1, further comprising:

positioning the test object relative to the at least one reference surface to cause the optical path length difference for each of the pairs of different surfaces in the set of cavity surfaces to differ.

28. The method of claim 27, further comprising:

positioning the test object relative to the at least one reference surface to cause contributions to the interference signals from second order reflections in the set of cavity surfaces to occur at frequencies that differ from the frequencies corresponding to the selected pairs of surfaces.

29. The method of claim 28, wherein the test object is positioned relative to the at least one reference surface such that the optical path lengths of successive, adjacent pairs of the cavity surfaces are substantially proportional to one another by a unique power of 3.

30. The method of claim 1, further comprising:

monitoring the frequency tuning with a wavelength monitor.

31. The method of claim 30, wherein the wavelength monitor comprises an interferometer.

32. The method of claim 30, calculating the frequency transform based on the monitored frequency tuning.

33. An interferometry method for characterizing a test object, the method comprising:

forming an optical interference image by combining different portions of an optical wave front reflected from multiple surfaces of the test object and at least one reference surface, the multiple surfaces of the test object and the at least one reference surface defining a set of cavity surfaces;

recording an interference signal at different locations of the optical interference image in response to tuning the frequency of the optical wave front over a range of frequencies, wherein the interference signal includes a contribution from each pair of different surfaces in the set of cavity surfaces;

transforming the interference signal into the frequency domain for at least one of the locations to produce a transformed signal having series of frequency peaks corresponding the pairs of different surfaces in the set of cavity surfaces;

identifying a frequency corresponding to each of one or more selected pairs of surfaces from the series of frequency peaks; and

determining an absolute optical thickness for each of the selected pairs of surfaces based on the corresponding identified frequency and the frequency tuning rate.

34. The method of claim 33, wherein the transforming, identifying, and determining steps are performed at multiple locations.

35. The method of claim 33, further comprising monitoring the frequency tuning rate using a wavelength monitor.

36. The method of claim 35, further comprising determining the frequency tuning rate based on the monitored frequency tuning.

37. The method of claim 35, wherein the transformed signal is produced based on the monitored frequency tuning.

38. The method of claim 33, wherein the one or more selected pairs of surfaces comprises multiple selected pairs of surfaces.

39. An interferometry system for characterizing a test object, the system comprising:

a frequency-tunable light source;

an interferometer comprising at least one reference surface, wherein during operation the interferometer directs different portions of an optical wave front derived from the light source to multiple surfaces of the test object and the at least one reference surface and recombines the different portions to form an optical interference image, the multiple surfaces of the test object and the at least one reference surface defining a set of cavity surfaces;

a multi-element photo-detector positioned to record an interference signal at different locations of the optical interference image in response to frequency tuning of the light source, wherein the interference signal includes a contribution from each pair of different surfaces in the set of cavity surfaces; and

an electronic controller coupled to the light source and the photo-detector, wherein during operation the controller, for each location, calculates a frequency transform of the interference signal at a frequency corresponding to each of selected pairs of the different surfaces in the set of cavity surfaces and extracts the phase of the frequency transform at each of the frequencies corresponding to the selected pairs of surfaces.

40. An interferometry system for characterizing a test object, the system comprising:

a frequency-tunable light source;

an interferometer comprising at least one reference surface, wherein during operation the interferometer directs different portions of an optical wave front derived from the light source to multiple surfaces of the test object and the at least one reference surface and recombines the different portions to form an optical interference image, the multiple surfaces of the test object and the at least one reference surface defining a set of cavity surfaces;

a multi-element photo-detector positioned to record an interference signal at different locations of the optical interference image in response to frequency tuning of the light source, wherein the interference signal includes a contribution from each pair of different surfaces in the set of cavity surfaces; and

an electronic controller coupled to the light source and the photo-detector, wherein during operation the controller: transforms the interference signal into the frequency domain for at least one of the locations to produce a transformed signal having series of frequency peaks corresponding the pairs of different surfaces in the set of cavity surfaces; identifies a frequency corresponding to each of one or more selected pairs of surfaces from the series of frequency peaks; and determines an absolute optical thickness for each of the selected pairs of surfaces based on the corresponding identified frequency and the frequency tuning rate.